CALIFORNIA DIVISION OF MINES AND GEOLOGY
FAULT EVALUATION REPORT FER-196

A Geomorphic Analysis of the Rose Canyon, La Nacion and Related Faults in the San Diego Area, California

by

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INTRODUCTION

This report is an outgrowth of the need to reevaluate some of the fault zones in the San Diego area. The Rose Canyon, La Nacion, and related faults were previously evaluated by Saul (1979a,b), based solely on the work of others. Since that time, faults which may have moved in Holocene time have been found in excavations in downtown San Diego and in Chula Vista. The evidence is questionable in each case and will be discussed later, but it was judged significant enough to warrant an updated evaluation. A statewide program requires the State Geologist to study faults which have been or may be determined to be sufficiently active and well-defined to warrant zoning. Current criteria require the fault to have moved in Holocene time and to be easily recognizable by identifying unique geomorphic features or unquestionable subsurface information. This program is called the Alquist-Priolo Special Studies Zones Act of 1972 and is described by Hart (1985).

Shortly after this reevaluation was started it became obvious that little was to be gained by another tedious review of the numerous published and unpublished reports which have dealt with the faulting problem in the San Diego Metropolitan area. What hadn't been done was a comprehensive regional investigation of the older aerial photography. This proved to be the most useful approach. Stereoscopic coverage, though not complete, is available from 1928 on and was invaluable for the study of areas where development had not yet occurred.

The evidence for activity of the Rose Canyon fault was reviewed and summarized by Treiman (1984) and will not be repeated here. This report should be available as soon as open-file report and currently is being revised for publication.

The faults that are analyzed here include the Rose Canyon, La Nacion, Texas Street, Florida Canyon, and other related faults. Existing geologic maps were used to locate faults for comparison with the photo images to see if any significant evidence of faulting is visible. The map compiled by Treiman (1984, plate 2) was used as a guide. The photos covering areas between the mapped faults were also inspected for the presence of features that might be due to faulting. Most of the areas covered by the following 7 1/2 minute quadrangles were studied on one or more sets of air photos. These are La Jolla, Point Loma, La Mesa, National City, and Imperial Beach quadrangles.

SUMMARY OF AVAILABLE DATA

A comprehensive review of the data bearing on the activity of the Rose Canyon fault was prepared by Treiman (1984) to assess the seismic hazard of that particular fault. He mainly concentrated on the Rose Canyon fault but reviewed most of the pertinent literature for the whole area and compiled a map showing most of the mapped faults in the greater San Diego area (1984, plate 2). A portion of that map is used as the base for recording the locations of the observations made in this report. Treiman's summary comments for 21 localities appear in the tabulation on Figure 1. The locality numbering system used by Treiman is continued here with a gap between 26 and 31 for possible use when he revises his 1984 report for publication. Locations used in this report and other data are shown in red on Figure 1.

Since the analysis of Treiman (1984), investigations at three sites revealed new evidence of possible Holocene faulting. At location 22 (Figure 1), a wide zone of north-trending faults were exposed in a large excavation for the Police Administration and Technical Center, which is located in the block bounded by Broadway and "E" Streets and by 14th and 15th Streets in downtown San Diego (Testing Engineers-San Diego, et al., 1985). The central or main fault bisects the site with an average strike of about N10°W and dip of 55°W to 75°W. The fault truncates a paleosol estimated to be 10 to 15 ka* and appeared to offset the base of a soil unit estimated to be between 3 and 5 ka. This is the youngest fault on the site. Upper Pleistocene units deeper in the excavation were offset progressively greater amounts by this fault, indicating repeated fault-rupture events. Although the main fault shows consistent down-to-the-west displacement, a mismatch of the various stratigraphic units suggests a horizontal component of displacement. Estimates of recency are based on relative soil dating techniques and on lithologic correlation with dated units elsewhere. No absolute dates were determined for units at this site. In reviewing the site for the City of San Diego, Leighton and Associates (1985) questioned the age assignments of most units (they thought they were too young) and the conclusions of Testing Engineers, et al (1985). No surface expression of faults was found in these studies.

A similar fault was observed on June 5, 1985, at a site-excavation for a warehouse on the northeast corner of 14th and "F" Streets, one block south of the Police site (E.W. Hart, personal communication, 1987). According to Sangines and Reed (1986), this fault had a trend of N17°W, dip of 75°NE, and apparent vertical separation of 18 feet in latest Pleistocene deposits. A soil estimated to be 3 ka to 5 ka was draped across the shear zone with one to 2.5 feet of elevation difference. They felt that the draping of the soil across the fault was not conclusive proof of recent faulting but was suggestive of it.

The Chula Vista fault was exposed in excavations for the South Bay Regional Center in 1979-1980 (location 61). This site is located south of H Street and west of Third Avenue in Chula Vista (Elliott, 1980 and 1985). The fault is normal with a N10°E trend and 65°W dip. It offsets a 25 ka unit 4.5 feet, giving a relatively low dip-slip rate. Radiocarbon dates of various

*ka = kilo anno or thousands of years before the present.
ma = mega anno or millions of years before the present.

units show only one soil unit to be Holocene in age (3,560 ± 170 years) and this unit truncates the fault and is not displaced by it. The youngest unit faulted was radiocarbon dated between 3.5 ka and 15 ka. It is possible that this fault could have moved in Holocene time but this can't be determined at this time. There is a very subdued elevation change which coincides with the exposed location of this fault and may be a broad fault scarp (see description for location 61 below.

The Linda Vista terrace is a geomorphic feature which is widespread in the San Diego area. It represents a period of marine planation when sea level was much higher than at present. The present elevation range is from approximately 500 feet at the eastern edge to as low as 200 feet at the western edge adjacent to the Rose Canyon fault. Its age decreases from east to west and the terrace is characterized by a series of well-defined beach ridges subparallel to the present coastline. The age of the terrace ranges from 1 ma* or older (Lajoie, et al., 1979) (location 32, Figure 1) to perhaps as young as 0.5 ma (Karrow and Bada, 1980; Demere, 1981). Other lower and younger terraces have been identified but are not pertinent here.

No unquestionable evidence for Holocene displacement on faults in the San Diego area has been found to date. The geological evidence is inconclusive. The geomorphic evidence is even less convincing and bears directly on the fault hazard analysis.

AIR PHOTO AND FIELD OBSERVATIONS

The following observations are based largely on a subjective evaluation of the characteristics which, from experience, are combined to limit the concept of "well-defined". This analysis is mainly based on the interpretation of pre-development air photos. The coverage from such photos is incomplete, but enough of the original ground surface can be seen to permit firm inferrences about scarps or scarp-like features, even where they are later obscured by structures. Many features seen clearly on older air photos are now obscured or obliterated by subsequent development. However, enough data are available to provide a clear conception of the general activity of faulting in the San Diego area. For the purposes of this analysis "well-defined" is used to describe faults where the trace is reasonably sharp, where multiple features common to fault geomorphology are present, and where some degree of continuity can be established. "Poorly-defined" is used to describe probable faults that have some continuity, but neither distinctive features nor significant sharpness (lack of erosional modification) are present. A general elevation difference may be present across a poorly-defined trace or one labeled not well-defined. "Not well-defined" implies the further uncertainty that these alignments are due to faulting or indicates they are eroded sufficiently to suggest that the features are quite old. Other explanations may be possible for these features or, where the fault has been observed on the ground or in outcrop, the scarp is even more subdued or may lack continuity more than one described as poorly-defined.

Early aerial photography, taken for stereoscopic coverage, is available from 1928 on. One set of air photos, taken in 1928-1929 are available for inspection at the San Diego County Engineer's Office. Other photos are in the Fairchild Collection held by Whittier College and those covering the period 1934-1951 were used. The coverage from these sets of

photographs is not complete but the 1928-1929 set is nearly complete. The U.S. Department of Agriculture flew complete coverage in 1953. High-altitude photo coverage was flown for the California Department of Transportation in 1964 (scale, 1:90,000). The other set with complete coverage was flown for the U.S. Geological Survey in 1980-1981. The amount of development that had occurred by then left little unmodified terrain to see on these photos. An annotated list of the air photo sets used in this study is included after the References Cited section.

List of locations observed on air photos and/or in the field.

The following location numbers are keyed to locations shown on Figure 1 in red.

(22) Police Administration and Technical Center site bounded by Broadway and "E" Street and 14th and 15th Streets. No fault features visible on air photos or on the ground. Photos used: SDC-1929; 66F6 and F7, 66E8 and E9 / AXN-1953; 3M-196 and 197 / GS-VEZT; (Line 24) 2-109 and 110 (Nov. 19, 1980).

Rose Canyon Fault

(23) Possible offset in Rose Canyon. Eastern edge of stream bank appears to be anomalously eroded in such a way as to suggest a possible right-lateral offset of a cut-bank meander. South along the fault projection a hill west of the trace appears to have a bench along the hillside; farther south an east facing scarp seems to mark boundary of offset terrace surface with a closed depression east of the fault; farthersouth terrace deposits and one drainage appear to be offset laterally. These features are seen best on the 1929 photos. The 1953 photos show only the general topography but none of the detail seen on the 1929 photos and the area is modified by construction to the point of obscurity. All natural features are obliterated by 1980. Photos used: SDC-1929; 59E6 and E7, 59F6 and F7 / AXN-1953; 4M-89 and 90 / GS-VEZT; (Line 22) 2-38 and 39 (Nov. 11, 1980).

(24) Hillside bench near but not on mapped trace of the Rose Canyon fault. Could be a differentially eroded contact or a fault related bench. Gullys and ridges which cross feature are not laterally offset. Photos used: AXN-1953; 4M-88 and 89 / SDC-1929; 52BX4 and BX5 / GS-VEZT (Line 22) 2-37 and 38.

(25) Possible fault trace visible on 1929 and 1953 air photos. Almost completely obscured by development since 1953. Access difficult due to gated residences and little original geomorphology is left by 1981. Fault can be traced for about 500 feet either side of point 25. To the northwest an alluvial fan appears to be offset and two steep drainages appear to jog right at the fault trace. To the southeast drainages appear to be deflected left at the possible trace of the fault. This is one of two locations in the San Diego area (the other is location 23) where features that may be recent were found. Vertical offset is suggested at this location, up on the north or downslope side, opposite to the prevailing opinion. These features cannot be traced beyond this limited location. Photos used: SDC-1929; 52BX2 and BX3, 52C1 and C2, 52C1 can be paired with 52BX3 directly and 52CA1 can be paired with 52BX3 if the

scales are matched, for a better image. AXN-1953; 8M-1 and 2 show the same features partly obscured by housing and not nearly as sharp as on older photos.

(26-31) These numbers are not used for locations in this report since they may be needed for locations in a revision of Treiman's (1984) report, now in progress.

(32) Higher portion of the Linda Vista terrace dated approximately 1ma or older (Lajoie and others, 1979). The Linda Vista terrace decreases in age from east to west and may be as young as 500-600 ka (Demere, 1981) toward the western edge. Younger terrace deposits range in age from 200 ka (Karrow and Bada, 1980) to perhaps 500 ka (Demere, 1981). Beach ridges on the lower reaches of the Linda Vista terrace are well-defined and appear to be as fresh or fresher than most of the fault features in the San Diego area. Photos used: Compare features seen on AXN-1953; 3M-102 and 103 or 3M-187 and 188 with photos used for locations 34 through 46 as well as other locations, particularly AXN-1953; 10M-1 and 2.

La Nacion Fault

(33) No fault trace evident north of Alvarado Canyon either in river terraces or older terrace deposits. However, a feature very similar to the mapped trace of the La Nacion fault to the south of here can be identified farther north. It appears to me as a possible ancient shoreline at the western edge of the Linda Vista terrace. It is more sinuous than the features to the south, called the La Nacion fault, and would be difficult to assume that it is a continuation of the La Nacion fault. See location 34 description for photo coverage.

(~~33~~ 34) Well-defined fault trace marked by possibly offset ridges, benches, notches and tonals along hillside. Fault appears to displace Linda Vista terrace as much as 5 m down to the west. Area is severely eroded and all geomorphic expression could be due to differential erosion along an older fault. No evidence of Holocene activity. One bothersome observation: the fault is less well-defined on the 1929 photos than on the 1953 photos suggesting erosional enhancement. Completely obscured on 1980 photos. Photos used: SDC-1929; 60C4 and C5 / AXN-1953; 14M-98 and 99 / GS-VEZT; (Line 26) 5-26 and 27 (Dec. 29, 1980).

(35) Poorly-defined fault trace on 1929 air photos. See location 34 description for further detail and photos used.

(36) Not well-defined on 1953 photos; obscured by development. Photos used: AXN-1953; 14M-99 and 100.

(37) Not well-defined on 1953 photos; obscured by development. Photos used: AXN-1953; 14M-100, 101, and 102.

(38) Not well-defined on 1953 photos; partly obscured by development. Photos used: AXN-1953; 14M-102 and 103.

(39) Poorly-defined on 1953 photos; partly obscured by development. Photos used: AXN-1953; 14M-103, 104, and 105.

(40) Apparent east-facing poorly-defined scarp on mapped trace of La Nacion fault. Photos used: SDC-1929; 67D6 and D7 / AXN-1953; 14M-104 and 105.

(41) Not well-defined on 1953 photos; obscured by development. Photos used: AXN-1953; 14M-104 and 105.

(42) Terrace deposits are not offset where these fault traces are mapped. Photos used: AXN-1953; 10M-116 to 118.

(43) River terraces not offset. Photos used: AXN-1953; 10M-116 and 117.

(44) Not well-defined on 1953 air photos. Difficult to locate on air photos, even though undeveloped, but a series of ridges possibly offset vertically in the Linda Vista terrace may be the surface expression of this fault. However, this does not fit the pattern of faulting suggested by previous workers as possible offsets of the ridges and terrace base are apparently up on the west not on the east. Obscure by development on 1981 photos. Photos used: AXN-1953; 10M-2 to 4 / GS-VEZT; (Line 28) 10-102 and 103 (Nov. 1, 1981).

(45) Poorly-defined on 1953 and 1981 air photos. Could be the trace of a fault here based on an elevation difference and possible offset (up on the east) of Linda Vista terrace. Could also be interpreted as an old shoreline here as trace is fairly straight; what appears to be a zone of sand or soft sediment is present; differential erosion occurs across the trace; and immediately west of and parallel to the trace are ancient beach-ridge remnants. Photos used: AXN-1953; 10M-1 and 2 / GS-VEZT (Line 28) 10-103 and 104 (Nov. 1, 1981).

(46) Not well-defined on 1953 and 1981 air photos. The fault trace here could be interpreted as an ancient shoreline with a less linear trace than shown for the mapped fault. The break in slope used to mark the fault trace can be followed around the noses of the hills affected but without detailed mapping and judging fromthe mapping of Kennedy and Tan (1977) which has attitudes on the fault and presumably is exposed at those location, a fault is presumed. This may be the most likely stretch to determine if there is both evidence for an old shoreline as well as faulting which could be closely related to the geomorphology seen on the air photos. This could be a classic case of fault control along an emerging shoreline. This stretch is partly obscured by development and freeway construction on the 1981 photos and may be completely obscured by now. Photos used: AXN-1953; 3M-44 and 45 / GS-VEZT (Line 28) 10-105, 106 and 107 (Nov. 1, 1981).

Balboa Park Graben

The graben between the west-facing Texas Street fault and the east-facing Florida Canyon fault, as shown by Treiman (1984, plate 2), is quite obvious on air photos, particularly on the 1:90,000 scale photos (FH-1964, Prints SD 12-16 and SD 12-18) which clearly show the near coincident elevation of the east and west side of the graben and the depressed and eroded central portion. The amount of offset of the Linda Vista terrace is probably less than has been presumed since the erosion in the graben has been severe toward the southern end and appears to

exaggerate the offset. The northern end is less eroded and probably represents the offset more accurately. The graben-bounding faults are not well-defined and recent features could not be seen.

Texas Street Fault

(47) Poorly-defined on 1953 air photos. Recognizable as a possible fault due to abrupt change in elevation across a linear feature but development has obscured any detail that might have been present. Photos used: AXN-1953; 3M-96 and 97 / FH-1964; SD 12-16 and 12-18.

(48) Poorly-defined on 1953 air photos. Recognizable from general change in elevation (west side lower) across linear feature. Where trace crosses northeast corner of Balboa Park the scarp is still reasonably unchanged but no detail suggesting recent activity can be seen either on the photos or on the ground. Photos used: AXN-1953; 3M-95 and 96 / FH-1964; SD 12-16 and 12-18.

(49) Not well-defined on any set of air photos. This projection from the more evident trace farther north is very questionable as it is badly eroded and gullied. Nearby gully margins, running parallel to this projection, are just as ill-defined and tend to obscure the graben floor here if it even extends this far. Photos used: AXN-1953; 3M-94 and 95 / FH-1964; SD 12-16 and 12-18.

(50) Poorly-defined fault on graben floor. This possible east-facing fault is as defined and as linear as the Texas Street fault. The terrace level to the west of this trace is not as high as the level east of the Texas Street fault. The area between appears to be a relatively flat terrace remnant also but no detail of faulting is visible. This alignment was not previously mapped as a fault but it qualifies as well as the other mapped faults in this area. Photos used: AXN-1953; 3M-96 and 97 / FH-1964; SD 12-16 and 12-18.

(51) Poorly-defined questionable fault on graben floor. This short trace appears as defined as the other faults in the area but could also be an erosional channel. It looks different than some channels nearby and is only pointed out because it may bea branch of the fault described in item (50). Photos used: AXN-1953; 3M-193 and 194 / FH-1964; SD 12-16 and 12-18.

Florida Canyon Fault

(52) Poorly-defined fault trace on 1953 air photos. This stretch of the east-facing fault is reasonably well-defined and might be so classified if it were not covered by houses and streets. No detail can be seen and the main evidence for faulting is linearity and the apparent offset of the Linda Vista terrace surface - west side higher. Photos used: AXN-1953; 3M-193 and 194 / FH-1964; SD 12-16 and 12-18.

(53) Poorly-defined on 1953 air photos. The scarp here is more subdued and has been affected by erosion. A drainage channel borders the fault on the graben floor and gullys cut the scarp. There may be some landslides present along the scarp also and the scarp elevation has been exaggerated by erosion. Photos used: AXN-1953; 3M-194 and 195 / FH-1964; SD 12-16 and 12-18.

(54) Not well-defined on 1953 air photos. The scarp here is severely eroded and gullied and the exact location is doubtful. None of the gullys appear to be offset or to have anomalous gradients. The main drainage along the faults has modified the terrain sufficiently to make the fault location suspect and further exaggerates the height. Photos used: AXN-1953; 3M-194 and 195 / FH-1964; SD 12-16 and 12-18.

Other faults and scarp-like features

(55) Unusually straight channel bank. This is most likely an erosional feature but it does appear more linear than other channel banks. There may be a slight possibility it could be fault controlled since it does seem to have an en echelon right step between two straight segments. Photos used: SDC-1929; 67D1 and 67D2 / AXN-1953; 3M-93 and 94 / FH-1964; SD 12-16 and 12-18.

(56) Poorly defined east-facing fault. This alignment of east-facing scarps is most likely a fault. Even though it is eroded and forms a channel bank toward the south end it appears to be a fault. A drainage, which now cuts through the higher western block, was previously diverted by the scarp and flowed southward along it. A much larger drainage crosses the south end of the fault but a remnant of the scarp is still present south of this drainage. Ponded alluvium or marine sediments obscure any further evidence beyond this remnant. Photos used: SDC-1929; 67D2 and D3 / AXN-1953; 3M-93 and 94 / TH-1964; SD 12-16 and 12-18.

(57) East-facing scarp or beach ridge. This feature can only be seen on the 1929 air photos and is noted here because of its proximity to the fault at location 56. It is most likely a beach ridge but not enough of the feature is unobscured by man to be sure. The amount of elevation difference, west side higher, is similar to other beach-ridge remnants farther south in the bay and water is ponded along its landward side but the typical beach-ridge slope to the west is obscured and cannot be determined. The possibility that it may be a fault or fault controlled cannot be dismissed. Photos used: SDC-1929; 67C2 and C3, 67D1 and D2.

(58) Eroded channel bank. This is obviously the cut bank of a drainage channel and is included as a means of discussing a more general observation. Many of thedrainages in the San Diego - National City area are anomalous. They drain in a southerly direction across the general slope; the westerly bank is the one that is actively eroding, or was until the area became developed; and the west bank is commonly higher than the east side. All of these features suggest the possibility of fault control - either a Holocene influence or an older pattern such as resistent beach ridges imprinted on the terrain which still influences the erosional pattern. This is a subject worthy of further study and may hold the key to Holocene fault activity. Photos used: SDC-1929; 67B2 and B3 / AXN-1953; 3M-91, 92 and 93.

(59) Beach ridges of probable Holocene age. These two scarp-like features appear to be older beach ridges with profiles typical of such features (see location 60 for detailed description). These have steep east-facing fault-like shoreward edges, gentle seaward slopes, and the slight increase in elevation shoreward necessary for preservation.

Photos used: SDC-1929; 67A1 and A2, 77F1 and F2 / AXN-1953; 3M-89 and 90 / FH-1964; SD 12-4 and 12-5 / GS-VEZT (Line 25) 2-115, 116, and 117 (Nov. 19, 1980).

(60) Beach ridges of probable Holocene age. The beach ridges or beach-ridge remnants shown here represent five periods of relative stability not including the present beach with its own ridge. There seems to be a slight increase in elevation to the east (landward) but formation of beach-ridges in this area is complicated by the proximity of and possible interaction with the Tijuana River and the southern San Diego Bay. This sequence of ridges may reflect some regional tectonic control also. If they are constructional only, the difference in elevation should be very limited. They are higher than the present shoreline beach and seem to increase in elevation landward suggesting some regional uplift. Episodic periods of uplift due to nearby tectonic events could produce a sequence of ridges like these. If this problem could be sorted out it could shed some light on the possible tectonic influence on the formation of San Diego Bay and the adjacent area. The beach ridges have the typical steep landward (eastern) profile and slope gently downward to the west (seaward) until the next ridge is encountered. The steep parts of each ridge are relatively straight and continuous and are as well-defined as some fault scarps. In fact the fault scarps in the San Diego area are not as well-defined as these beach ridges which are composed mainly of soft sand. Photos used: SDC-1929; 77A2 and A3, 77B1, B2 and B3 / AXN-1953; 3M-41 and 42 / FH-1964; SD 12-4 and 12-5 / GS-VEZT's (Line 25) 2-115, 2-116 and 2-117 (Nov. 19, 1981), (Line 26) 5-35 and 5-36 (Dec. 29, 1980).

Chula Vista Fault

(61) Chula Vista fault scarp. This fault, first recognized in an excavation southwest of "H" Street and 3rd Avenue in Chula Vista (Elliott, 1980) can be correlated with a trend, visible on air photos and in the field, marked by a general difference in elevation - east side higher than the west side. This presumed fault shows up more clearly on later air photos because, subsequent to the 1929 photos, development has apparently cut into the scarp and modified the trace. On the 1929 photos it is poorly defined. Photos used: SDC-1929; 67A2, A3 and A4, 77F3 and F4 / AXN-1953; 14M108 and 109 / GS-VEZT (Line 26) 5-33 and 34 (Dec. 29, 1980).

(62) East-facing scarp. This probable fault scarp and the one at location 63 are reasonably sharp but eroded or slumped to the angle of repose and are here classified as poorly defined. They have been isolated from adjacent drainages and are not now being actively eroded. However, they seem to mark the eastern boundaries between two tilted blocks with possible remnant terrace surfaces on them. These blocks are tilted downward to the west - the faults being relatively downdropped on the east.

(63) East-facing scarp. See description of location 62. Area now covered with houses and roads. Photos used: AXN-1953; 3M-43, 44, and 45 / FH-1964; SD 2-4 and SD 2-122 / GS-VEZT (Line 27), 5-41 and 42 (Dec. 29, 1980).

(64) Poorly-defined faults in Linda Vista terrace surface. These faults offset blocks of terrace deposits and underlying rocks but do not displace adjacent river terraces. Some traces extend into Mexico but are not visible for more than a kilometer. Photos used: AXN-1953; 3M-32, 33 and 34 (Blanked out at border) / FH-1964; SD 12-4 and 12-5 / GS-VEZT (Line 26) 5-36, 37 and 38 (Dec. 29, 1980).

(65) East-facing scarp here may be an extension of the Florida Canyon fault or other east-facing systems to the south. Drainages crossing this area are disrupted at this trace and the fault displaces terrace surface, west side up. This is not a beach ridge and is well-defined. Destroyed by development and not visible on 1964 photos. Photos used: FW-16960 (flown Sept. 7, 1951-not available for circulation); 1-5, 6 and 7 / AXN-1953; 3M-189 and 190.

CONCLUSIONS

The recency of faulting in the San Diego area has generated a great deal of controversy. This study has attempted to evaluate the faults in the area from the point of view that assumes recent activity should produce geomorphic features that can be seen by inspection of stereoscopic images visible on aerial photographs. Such features are a common occurrence in most of California and it is possible to subjectively estimate the recency of activity from these and other data. None of the features seen on the sets of air photos studied or on the ground would suggest any activity that is obviously Holocene in age. Some features, such as seen at location 23, 25, and 65 may be Holocene, but could be questioned on the basis that they are remnants of older movements that are fortuitous occurrences that have been isolated by erosional processes. Supporting this theory is the complete lack of any continuity between these features or other even questionable features. Continuity is very important in the analysis supporting the concept of both well-defined and sufficiently active.

Continuity is almost completely lacking on most faults in the San Diego area. The La Nacion fault may be more continuous than most but is not a very active fault. It is less well-defined than features such as ancient beach ridges that may be more than half-a-million years old. Many of the other faults in the San Diego area are not any more well-defined than these beach ridges.

Some features, such as groups of drainage channels that all seem to be deflected may be related to tectonic processes, but this cannot be determined from the evidence at hand. It is my admittedly subjective opinion that faults in the San Diego area are not very active. Some activity may have occurred in early Holocene or late Pleistocene time. If they have been active in Holocene time the amount of erosion taking place is sufficient to obliterate most of the evidence faster than it accumulates. The other possibility is that the amount of movement is very small in each event and may be of a degree suggesting minor creep or triggered slip from other seismic sources, perhaps offshore.

RECOMMENDATIONS

No special studies zone are recommended at this time on any faults in the San Diego area. It is particularly difficult to zone faults that may

be proven to have Holocene offset but have no surficial features even on pre-development photos. Where man has modified the surface the problem is multiplied and continuity may be lost making it permanantly impossible to find enough evidence to support zoning.

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Report reviewed & approved.
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Testing engineers - San Diego, Dames and Moore, and Woodward-Clyde Consultants, 1985, Geologic and fault investigation, San Diego Police and Administration and Technical Center, San Diego, California: Unpublished consultants report for Starboard Development Company, San Diego, California, 55 p., 17 plates, 3 appendices.

Treiman, J.A., 1984, The Rose Canyon fault zone, a review and analysis: Unpublished report, California Division of Mines and Geology for Federal Emergency Management Agency, Cooperative Agreement EMF-83-K-0148, 106 p., 2 plates.

Air Photo Sets Used

SDC-1929: San Diego County Engineers Office.
Flown Nov. 1928 to Mar. 1929. West to east direction. Scale approx. 1:13,000 ± 2,000 (Nominally 1:12,000). Format 8 x 10 inches, limited stereo overlap. Coverage originally meant to be complete but only prints are now available and many are missing. Overlap nominally 50% plus but some are less hence some stereo is lost. Used extensively for selected observations.

FW-1980: Fairchild Collection - Whittier College.
Flight #1980. Flown Feb. 26, 1932. Scale 1:9,600. Format 8" x 10", stereo overlap. Coverage limited to Soledad Valley and coast line to Del Mar. Nothing resembling fault scarps or even questionable features.

FW-3069: Fairchild Collection - Whittier College.
Flight #3069. Flown July 17, 1934. Scale 1:14,400 (Index says 1:9,600). Format 8" x 10", stereo overlap. Selected coverage of the El Cajon area, only 24 prints. Checked carefully, saw nothing that could be ascribed to faulting.

FW-5984: Fairchild Collection - Whittier College.
Flight #5984. Flown Aug. 4, 1939. Scale 1:7,200. Format 9" x 9", stereo overlap. Coverage mainly flood plain of Tijuana River and Mexican border area. Faults south of river show fairly well.

FW-6850: Fairchild Collection - Whittier College.
Flight #6850. Flown Jan. 3, 1941. Scale 1:18,000. Format 9" x 9", stereo overlap. Selected coverage from Del Mar to Balboa Park. Texas Street fault visible and some beach ridges on Linda Vista terrace.

FW-7117: Fairchild Collection - Whittier College.
Flight #7117. Flown May 21, 1941. Scale approx. 1:8,000. Format 9" x 9", stereo overlap. Covers Imperial Beach and Tijuana River area but nothing visible on these photos not seen on 1929 or 1953 air photos.

FW-16960: Fairchild Collection - Whittier College.
Flight #16960. Flown Sept. 7, 1951. Scale 1:12,000. Format 9" x 9", stereo overlap. Coverage vicinity of Montgomery Field. Shows questionable feature which could be northward extension of Florida Canyon trend. Multiple shoreline features in vicinity of Montgomery field show also on 1953 photos.

AXN-1953: U.S. Department of Agriculture.
Contract No. AXN PMA-29-53. Flown March-May, 1953. Scale 1:20,000. Format 9" x 9", stereo overlap. Complete coverage of San Diego area. Earliest complete coverage available.

FH-1964: Fairchild Aerial Surveys for California Division of Highways.
Contract A.S.C. No. 676-4. Flown Oct. 10 or 21, 1964. Scale 1:90,000. Format 9" x 9", irregular stereo overlap. Complete coverage of area studied. This series is indexed as to County (in this case San Diego [SD]). The overlap is much greater than normal so only every third or fourth print is needed for near normal stereo. This series is very valuable for more regional relationships.

GS-VEZT: U.S. Geological Survey.
Flown in two steps; Nov.-Dec. 1980 and Nov. 1981. Scale 1:24,000. Format 9" x 9", stereo coverage. Complete coverage but because apparently some photos are repeats of areas where originals were unsuitable, an index is essential. Used mostly to see what areas might be undeveloped in order to look at certain features in the field.